

Making International Collaboration Work in Earth Observation:

A View from Brazil

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1 Introduction

International co-operation is one of the key issues in civilian earth observation (EO) programmes. Given the globalised nature of data collection for earth observation satellites, the “public good” contribution of most programmes, and the high cost of building and maintaining a remote sensing programme, it is natural to expect that most satellites would be based on extensive international collaboration, involving governments and private companies. As stated by one of the EO industry leaders, “EO is a global business so international collaboration is destined to play a pivotal rôle in establishing a viable EO business model” (MacDonald 2002). In spite of these perspectives, much of the promises of international collaboration in earth observation remain unfulfilled, especially in relation to truly multilateral agreements involving countries from the G-7 and DSP¹ (developing nations with active space programs). This paper examines some of the reasons that have contributed to this situation, and explores ways in which international co-operation in space observation can be improved, proposing both a short and a medium term agenda for collaboration. Our analysis is based on a framework that enables an assessment of international collaborative programs in earth observation, by considering the relative importance of the factors affecting a country’s decision to engage in a co-operative program.

This paper is written based on the experiences of the Brazilian space program, but we hope that our rationale and conclusions are applicable in a more general context. We

¹ In this paper, the denomination DSP (developing countries with space programs) has been adopted to include all countries outside of the G7 that have or aim at having significant space programs. This includes nations such as Argentina, Brazil, China, India, Indonesia, Iran, Israel, Pakistan, Russia, South Africa, South Korea, and Ukraine, among others.

have, of course, based our concepts on experience from some noteworthy EO international collaborations programmes in which Brazil is involved, including:

- (a) Reception and dissemination of LANDSAT images: INPE (Brazil's National Institute for Space Research) has been active in LANDSAT data collection and dissemination continuously since 1974, resulting in one of the largest archives of remotely sensed data in the world. Amongst the numerous applications developed in Brazil, the annual comprehensive assessment of deforestation in Amazonia stands out as one of most extensive uses of LANDSAT data ever.
- (b) Development of the CBERS series of satellites built in co-operation with China. The CBERS-1 satellite has been launched in October 1999, carrying a CCD detector with 4 multispectral bands and 1 panchromatic band with 20 meter resolution for the visible and near infrared regions, an MSS detector with 80 meter resolution (visible and mid infrared), both with a 120 km swath and a WFI (wide field imager) with 200m resolution, two spectral bands and 800 km swath. The CBERS-2 satellite is scheduled for launch in August 2002, with two follow-on satellites (CBERS-3 and 4) with improved spectral and spatial resolution to be launched later in this decade.
- (c) Reception and Dissemination of RADARSAT: Brazil is actively engaged in the RADARSAT program since its conception. By agreement with the Canadian Center for Remote Sensing (CCRS), an airborne SAR mission (SAREX) was flown over Brazil in 1992, enabling Brazilian and Canadian researchers to explore ways of using SAR data in a tropical environment. Brazil has a strong SAR application community, including active participation from the private sector, such as the petroleum company PETROBRAS.

It should be pointed out that the Brazilian space program is entirely focused on civilian applications, and is controlled and financed exclusively by the Ministry of Science and Technology. Brazil has long since repudiated any aggressive intentions and has been accepted as a full member of the MTCR (Missile Technology Control Regime) in 1995. Therefore, this work is focused on the establishment of international co-operation programs aimed at civilian EO applications.

2 A Framework for Assessing International Co-operation

In order to assess international collaboration programmes in EO, we propose a framework based on the concepts developed by Michael Porter for evaluating a nation's competitiveness. Taking a public-policy perspective, we consider that there are four main factors that influence a country's decision to initiate and sustain international co-operation in EO:

(a) Strategy: By strategic factors, we refer to the impact of the program in the nation-wide policymaking. This involves questions such as: When the two presidents of the involved countries meet, how often is the program included in their discussion agenda? Is the program seen as influencing positively the commercial balance of trade between the two countries? Does the program contribute to the country's national pride? Is the imagery provided unique and capable of making a significant contribution to the management of country's territory? Can the data acquired be used for international agreement with third-parties?.

(b) Industrial Innovation: By industrial factors, we consider the expected impact of the program in fostering innovation in its high-technology sector. Since most of the countries involved in medium and large-scale space programs also have an established aeronautics industry (as in the Brazilian case), government strategists expect some form of spillover effect from the space program into other sectors of the economy. Most governments are reluctant to spend public funds in supporting high-technology jobs abroad, if there is no local compensation. Without some form of tangible compensation for the local high-technology industry, it is unlikely that a government will agree on an international EO program.

(c) Societal Benefits: Earth observation satellites are primarily artefacts for producing public-accessible data, which has a strong "public good" component. Assessment criteria include: (a) proven applications that can be derived from satellite imagery; (b) data reliability and quality of data; (c) data continuity. This latter condition is especially important in large countries such as Brazil, in which long-term monitoring of environmental and urban patterns plays a very important role in public policy issues.

(d) Cost: To this day, most international EO programs have not yet proven to be fully commercially viable without some form of government intervention. Therefore, the right question to ask may not be "*how much does the program cost?*" but rather "*what fraction of a country's R&D budget is being committed to the program?*". In many countries, EO programs are still considered to be R&D investment, and therefore allocation of funds has to consider competing alternatives such as biotechnology, nanotechnology or information technology.

These four factors can be combined visually in what we describe as the "EO-diamond". For that purpose, each factor is ranked in a [0..1] scale, and the resulting figure is displayed as a diamond, where the cost factor is ranked in inverse proportion to the country's expenditure on the program. For example, Figure 1 shows our assessment of the benefits of the LANDSAT program to Brazil since 1974, which was based on the following grounds:

- (a) **Societal Benefits (0.95):** LANDSAT has played a very positive rôle in helping Brazil manage its large territory, including regions with limited population and difficult access, such as Amazonia.
- (b) **Cost (0.75):** The LANDSAT program has cost Brazil on the order of US\$ 60 million in 18 years, mainly related to the acquisition of ground stations and satellite access fees. This is a very reasonable investment, and amounts to a small fraction of Brazil's expenditure in space in the same period.
- (c) **Strategy (0.6):** LANDSAT provided the foundation for the establishment of the Brazilian Earth Observation program, including ground stations, distribution network, and application development. The LANDSAT program status in the US administration has undergone many changes recently, and perhaps for this reason, LANDSAT is currently not very highly placed in the cooperation agenda between the two countries.
- (d) **Industrial Innovation (0.3):** There has been little industrial innovation directly linked to the LANDSAT program in Brazil. Nevertheless, the need for extracting information from LANDSAT data led Brazil to develop a significant effort in Image Processing and GIS technology, which has resulted in full autonomy and international competitiveness in this area (Câmara et al. 1996).

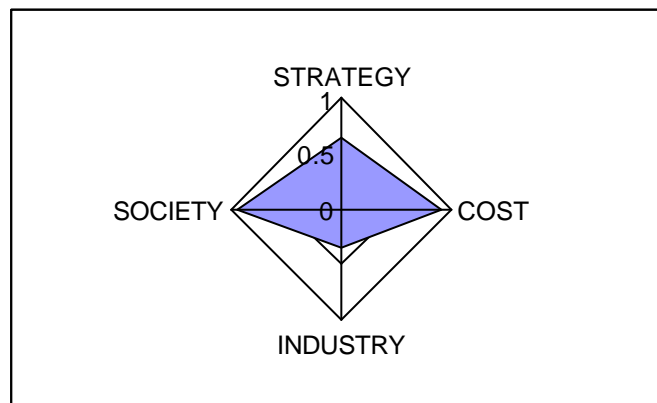


Figure 1 – "EO-diamond" showing assessment of benefits of the LANDSAT program to Brazil (1974-2002).

In a similar fashion, an assessment of the *expected* benefits of the CBERS program for the period 2000-2010 is shown in Figure 2. The *strategy* component of the CBERS program is very high (1.0), since it forms the most important international agreement between the Brazilian and Chinese governments. Since CBERS will demand a significant portion of the Brazilian space budget, the *cost* of the project gets a low mark (0.3). The *societal* benefits are expected to be high (0.8), since CBERS images can be subject to Brazil's own dissemination policy that will emphasise wide use of the data by

the Brazilian society. The *industry* innovation aspects are also forecasted to be high (0.65), reflecting the emphasis on using locally developed technology.

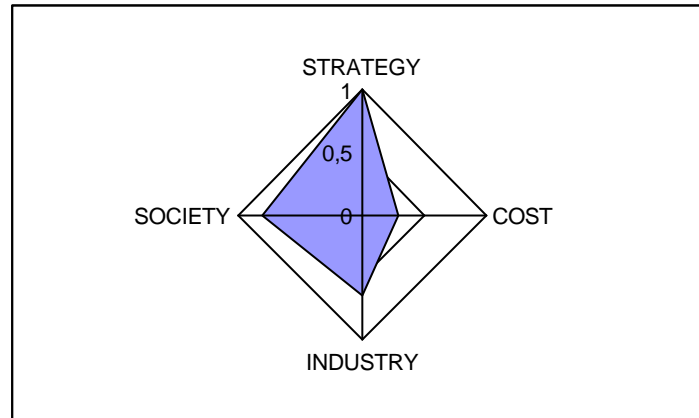


Figure 2 – “EO-diamond” showing assessment of expected benefits of the CBERS program to Brazil (2000-2010).

3 How Can International Collaboration Work in EO?

It is now time to return to the main topic of this work, and analyse the impact of the “EO-diamond” in terms of the decision-making process for two countries (or a G-7 company and a DSP country) to enter into an international partnership. Based on the proposed framework, the straightforward answer to the question: “*how can international collaboration work in EO?*” would be “*when all four decision-making factors (strategy, industry, society and cost) have properly been taken into account and each partner is satisfied that his objectives are met*”. In practice, the answer is never as simple as that, but this approach requires a strong effort by negotiators to assess the other partner’s motivation. To that aim, we shall now consider some specific aspects of the EO technology and business model, by analysing each factor separately.

3.1 Improving International Co-operation: the Societal Benefits Factor

Benefits for the society will continue to be the main motivation of civilian EO programs. Therefore, it would be expected that improved satellite capabilities would be transformed into increasing market returns. This perspective has led governments in Europe and North America to actively encourage the rôle of private companies in transforming earth observation from a government-led program to a commercially-led one. In practice, recent reports indicate there is much uncertainty in terms of market growth for commercial EO companies (O’Connell et al. 2001). To a large extent, this uncertainty is caused by the market’s perception about the limitations of the information content of the satellite data (MacDonald 2002). Therefore, improving the societal benefits of EO requires substantial advances on the information extraction procedures

for remote sensing satellite data, as well as the removal of copyright restrictions on the data.

Information and copyright restrictions

Some commercial high-resolution imagery companies have adopted policies that severely restrict the use of their satellite data, by controlling the rights of redistribution and public dissemination and by denying access to spacecraft orbital parameters that could enable precise geometrical modelling of the images. By contrast, aerial imagery companies are much less restrictive on the dissemination of the data they generate and already provide the data integrated into a GIS, with full geometrical corrections applied. Studies carried out both in the US (O'Connell et al. 2001) and in Brazil (Freitas 2001) indicate that, given current practices of the high-resolution satellite companies, aerial imagery is fully competitive with high-resolution satellite images for most markets, especially for urban cadastral applications. Therefore, to increase their market share, commercial EO companies might have to change their practices, by being less restrictive on data dissemination, delivering data “customer-ready” with value-added content, and providing spacecraft orbital data to allow processing by customers and service companies (O'Connell et al. 2001).

Knowledge extraction from EO data

It has been recognised recently that there is a “knowledge gap” in the process of deriving information from EO data (MacDonald 2002). We consider that much of this “knowledge gap” has resulted from a market segmentation, in which satellite operators have concentrated on being data providers, and have entrusted image processing software companies with the task of supplying systems for information extraction. The main problem is that the market share that has been captured by the image processing companies remains small. According to an International Data Corporation (IDC) survey, the estimated global market for spatial information management systems had reached \$1.08 billion in 1999, and was forecast to reach \$2.1 billion a year by 2004. ESRI, a leading provider of GIS software, had 1999 revenues of more than \$340 million, with 60 percent coming from the public sector. By contrast, ERDAS, the leading provider of image processing software, had US\$23.5 million in sales in 2000 with about US\$3 million in profit.

The small size of the image processing market has led to a “deadlock” situation: the current customer base does not provide enough income for image processing software companies to invest in new information extraction procedures. However, without significant improvements on information extraction, the civilian market for EO data will not realise its full potential and will not grow significantly, and thus will not generate the returns the industry needs to cover its R&D expenditure. Because of this deadlock,

image processing software technology has evolved very slowly in the last 10 years. The main recent area of investment has been the inclusion of digital photogrammetry techniques; however, such software is simply the translation of established procedures from the analogue to the digital world, benefiting aerial imagery as much as satellite data. In knowledge extraction procedures specific to satellite data, very limited technological innovation has taken place recently. To complicate matters further, there is currently little academic research in the key aspect of integration of satellite images with other types of geographical information (for some exceptions, see (Agouris and Stefanidis 1999), Câmara et al (2001) and Fonseca et al (2002)).

Breaking the current deadlock will require a concerted action in many fronts. First, EO data providers should acknowledge the fact that the current market segmentation is detrimental to their business and either: (a) establish partnerships with image processing software companies that encourage technological innovation, or (b) become value-added providers themselves. Secondly, government agencies should recognise that bridging the “EO knowledge gap” requires substantial research investment and should create specific funds to encourage academia to invest on problems related to the integration of satellite images with other types of geographical information. Finally, the EO customer base would benefit for the availability of a co-operative software development environment for knowledge extraction for EO imagery. In a similar fashion as the rôle played by the Linux operating system and associated tools on the IT market, such a co-operative image processing software environment would allow researchers to share their results with the EO community, thus reducing the “time to market” from academia to society.

3.2 Improving International Co-operation: the Industrial Innovation Factor

When considering improvements in the industrial innovation factor for international co-operation, it must be remembered that the EO industry is still very much funded and controlled by governments for two main reasons: space technology is seen as an important innovation front, with spillovers for areas such as IT and the aircraft industry, and is also considered a strategic field with strong impact on international relations. For example, in Europe, industry leaders expect the European EO program “to give Europe either autonomy or a balanced mutual dependence between global actors, combined with increased development of utilisations and commercial services” (Eurosace, 2000).

The industrial components of a typical EO program can be divided into two main segments: commodity-based components and critical technologies. The commodity-based segment includes items such as: solar panels, on-board computers, telemetry equipment for the space segment, and reception stations and image processing systems on the ground segments. These components have potential worldwide suppliers, and companies from Russia, India, China and Brazil are able to provide products suitable for most EO missions. In current practice, however, this commodity-based market is still

very heavily regulated, a situation which reduces competitiveness and increases cost. Should a trend for de-regulation of these segments become prevalent, one could expect a consolidation process not unlike what is happening in the aircraft industry. This process could even lead to high-tech industries in developing countries becoming major suppliers in some products, following the example of the Brazilian company EMBRAER in the aircraft marketplace (for a more detailed analysis of the EMBRAER case, see Goldstein, 2001). International co-operation programs could be a way towards achieving such de-regulation in stages, where confidence building could result in a growing participation of industries from non-G7 countries in international EO missions, thus achieving a “balanced mutual dependence”.

The second major type of industrial components in EO programs is critical technologies, such as guidance systems and high-quality optics and electronics. In this case, when negotiating an international program, most countries and companies tend to be very restrictive of such technologies. However, no country that aspires to use EO technology to be part of the global balance of power, even if aiming at civilian applications only, can afford to be completely dependent on such critical technology. Also in this case, a step-by-step confidence building process brought about by long-term co-operation agreements might prove valuable in reducing tensions and easing technology transfer.

3.3 Improving International Co-operation: the Strategic Factor

When establishing an international co-operation program in EO between two countries, the most important strategic factor concerns their diplomatic and economic relations. From a government’s perspective, EO programs (with their strong “public good” component) are also seen as a means of diversifying their international partners. The establishment of partnerships between DSP countries, such as the CBERS China-Brazil earth resources satellite, has shown that high-technology development can happen outside of the G-7 world and might, in some cases, bring more innovation benefits. The successes of such partnerships suggest that negotiations between G-7 and DSP countries will take a different shape that what was the case a decade ago, where some DSP countries were seen mainly as a market for EO data. Countries with established space programs will tend to be more demanding in technology transfer and access to G7 markets, given that there are more alternative partnerships available.

3.4 Improving International Co-operation: the Cost Factor

The intangible nature of societal benefits of EO programs, the strategic value of international agreements and the spillover effects of the space industry indicate that cost is the least independent component of the “EO-diamond”. In theory, international co-operation could help reduce the costs associated to an EO mission, by dividing the responsibility amongst the partner countries and their industries. However, the process

can also induce relative distortions, since resources appropriated by each partner may not be used in fully international competitive invitations to tender, but rather allocated to that country's industry.

The major factor in cost reduction resulting from international collaboration would be productivity gains resulting from scale effects. Should such a consolidation occur in the EO industry, the result might be a specialisation process, where each major component of a EO mission would be available from a small number of industries, a situation that could reduce cost without compromising quality. It appears, however, that the international state of affairs is not yet prepared for this consolidation to happen.

4 International Collaboration at a Global Scale: Utopia or Possible Realization?

So far, we have mainly looked at establishing alliances where two sides are involved, considered the motivating factors for each party, and argued that all these factors must be contemplated for a significant collaboration to take place. In this section, we take a broader view and investigate whether there are ways forward involving many countries and companies. We start by asking: *'How many EO satellites does the world need?'* This is a utopian, but not superfluous question. A similar problem has been posed (and solved) in the case of geostationary meteorological satellites. Full global coverage (excluding the polar regions) requires at least five geostationary satellites in orbit at any one time. The Coordination Group for Meteorological Satellites (CGMS) has agreed that operational responsibility for these five satellites is shared by four satellite operators: EUMETSAT, Japan, Russia (each with one satellite committed to operations) and the USA (with two satellites in orbit). An experimental geostationary meteorological satellite has also been launched by China, while India maintains a multipurpose satellite with meteorological capabilities but reserves it mainly for national use. Could a similar arrangement as the CGMS be reached in the EO sector? In theory, given that the Earth is a finite place, an optimal configuration of EO satellites is possible, covering different ends of spectrum (optical, infra-red, thermal and microwave) and with complementary spatial and temporal resolutions. The existing framework of the Committee for Earth Observation Satellites (CEOS) could be used to develop such an arrangement. Given the expected technological advances in the next 10 years, many countries, some with existing space program and some with emerging space activities, could contribute to this global, concerted effort. Countries would not required to abandon their existing international partnerships but rather would adapt their planned EO missions to a global level of complementary configurations.

From an EO applications perspective, the first decade of the 21st century is a most promising one. The continuation of the LANDSAT-class satellites (with LANDSAT-8, SPOT-5, CBERS and IRS), the experience with C-band and L-band polarimetric radar

images to be brought about by RADARSAT, ENVISAT and ALOS, the high-resolution imagery of IKONOS and QuickBird, the availability of the hyperspectral images of MODIS and of the multispectral thermal infra-red bands of ASTER are bound to give the EO researcher more data than he may ever have imagined. This embarrassment of choices might also prove a breeding ground for the establishment of large-scale cooperation in EO, in which a concerted multilateral effort could provide countries with enormous environmental and urban problems such as most African nations with much needed information, and where humanity as a whole could benefit from the promises of earth observation.

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